VACUUM INSULATED QUARTZ TUBE HEATER ASSEMBLY

RELATED APPLICATIONS

This application claims the benefit of U.S. Provisional Patent Application Serial No. 60/426,779, filed November 15, 2002, which application is incorporated herein in its entirety.

BACKGROUND OF THE INVENTION

The present invention generally relates to a heater assembly and, more particularly, to a vacuum insulated quartz tube heater assembly for heating fluids and objects.

The use of quartz glass to encase a heater element is known in the art, since quartz glass has the ability to sustain the high temperatures that are generated by the heater, while the quartz glass is relatively chemically inactive. Typically, electrically resistive wires, ribbons, and coils have been used as heater elements within quartz heaters to generate the required heat.

Recently, conductive metal oxide films (coatings) have been employed as heating elements, where the films are generally disposed on glass. One of the methods for depositing the films has been to spray coat the films onto the glass. More recently, the depositing of the coatings has improved, for example, through the use of chemical vapor deposition (CVD).

An application of quartz glass that would benefit from the employment of the use of the conductive coating as a heating element would be a quartz glass heater for the heating of a fluid or other material as the fluid would flow through the quartz glass heater. In such a heater, the heating element would need to elevate the fluid temperature as the fluid would pass through the heater.

If a quartz glass heater, using a thin film conductive coating, could be constructed it would be an improvement over the conventional heater element, since the conventional wire, ribbon, or coil elements are more costly, more bulky, and add weight to the heater assembly.

However, achieving such a deposition on curved quartz glass has proven to be difficult. This is due to the fact that the conductive coating must be uniformly disposed upon the quartz glass in such a manner as to properly electrically section off the conductive coating, while achieving a necessary resistive load for the desired output power.

In addition, expanding the adoption of this technology is hampered by the complexity of safely, reliably, and cost effectively combining glass and electricity. Because of the high temperatures that are generated by the heater, the chemical reactivity of the parts of the heater, along with the atmosphere within the heater, become important factors affecting the reliability of the heating assembly.

If the parts and/or atmosphere within the heater assembly are not properly chosen the high heat will cause the materials and the atmosphere to interact and lose their functionality, which will shorten the life of the heater assembly. In the past, conventional quartz glass heating elements have been disposed within a vacuum. As a result, the quartz glass, which has a low chemical reactivity, the vacuum/atmosphere within the quartz heater, and the various parts within conventional quartz glass heaters would have to be properly chosen in order to provide better reliability for the heater assembly.

Thus, those skilled in the art continue to seek a solution to the problem of how to provide a better vacuum insulated quartz glass heater assembly.

SUMMARY OF THE INVENTION

The present invention relates to a vacuum insulated heater assembly that is used for heating fluids and objects. The heater assembly includes an inner member (heating element), for example, a quartz glass tube, where at least a portion of a major surface has a conductive coating disposed thereon. Electrical connection to the conductive coating can be made by at least two connection means (connections) that are disposed onto and are in electrical contact with the conductive coating. The connection means are disposed in such a manner as to define a set of parallel heating sections that provide the desired heating elements for the

heater assembly. Consequently, an external power source is electrically connected to the connection means.

At least two end caps, each with a major inner member void defined within, are disposed on separate end portions of an outer member, for example, a quartz glass tube. The inner member is positioned within the outer member and mechanically attached to and extending through the end caps' major voids. In addition, the end caps have minor voids defined within that provide wire pathways, and vacuum drawing and sealing means for drawing and sealing a vacuum within the space defined between the outer and inner elements.

With the inner member having an axial void defined therethrough, the heater assembly would be used to heat material, for example, fluids, as they would flow through the axial void of the inner quartz glass tube. If the major surface of the inner member is not completely coated, then the heater assembly can be used to heat objects.

Further advantages of the present invention will be apparent from the following description and appended claims, reference being made to the accompanying drawings forming a part of a specification, wherein like reference characters designate corresponding parts of several views.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a partial side/partial cross-sectional view, taken in the direction of the arrows along the section line 1-1 of Fig. 2, of a vacuum insulated heater assembly in accordance with the present invention; and

Fig. 2 is an end view of the vacuum insulated heater assembly of Fig. 1.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

In general, the present invention involves the use of a vacuum insulated heater assembly 10, as shown in Fig. 1, for heating fluids and objects. Shown in a side view is an inner member 14 (heating element), for example, a quartz glass tube. Provided thereon is a conductive coating 34, for example, a doped metal (tin) oxide, like a fluorine doped tin oxide, that has been disposed on at least a portion of a major surface 36 of the inner member 14. A special rotating fixture (not shown) can be used to rotate the inner quartz glass tube 14 in a chemical spray booth, as one method of deposition of the conductive coating 34, where nominal sheet resistance of approximately 25 ohms per square can be attained. Alternate methods of deposition could be conductive coating chemical vapor deposition (CVD) or spray pyrolysis.

At least two connection means 32 (connectors), for example, compression fittings with a conductive wire mesh or

conductive metal bus bars, for example, ceramic silver frit or sprayed metal copper, could be disposed onto and placed in electrical contact with the conductive coating 34 (see U.S. Provisional Patent Applications Serial No. 60/339,409, filed October 26, 2001, and Serial No. 60/369,962, filed April 4, 2002, and U.S. Utility Patent Application Serial No. 10/256,391, filed September 27, 2002, which applications are included herein by reference), wherein heating head and mask apparatus are utilized to dispose metal bus bars on electrically conductive coatings 34.

As additional and approximately equally spaced coating connection means 32 are added, sets of parallel heating sections are defined that lower the overall resistance and consequently increase the heat generation for a given power supply (not shown). Note that for a given voltage and size of inner member 14, the heat (Q) generated is directly proportional to the number (n) of equal parallel resistors (heat sections). For example, six equal heat sections will generate approximately three times the amount of heat that two equal heat sections will generate rate (i.e., $Q\alpha n$). Note, however, that unequal heat sections are within the spirit and scope of the present invention.

As a result, the present invention provides precise heating elements for the vacuum insulated heater assembly 10. Consequently, the connection means 32 are electrically connected to conduction means 26, for example, heater wires,

and to an external electrical power source for powering the vacuum insulated heater assembly 10.

The inner quartz glass tube 14 is mechanically attached to and extends through major end cap voids in at least two end caps 16, 18 (shown in Fig. 1 in a cross-sectional view, taken in the direction of the arrows along the section line 1-1 of Fig. 2), for example, frit glass disks. The assembly of the inner quartz glass tube 14 and the end caps 16, 18 is positioned within an outer member 12 (shown in Fig. 1 in a cross-sectional view, taken in the direction of the arrows along the section line 1-1 of Fig. 2), for example, a quartz glass tube 12, where the end caps 16, 18 make mechanical contact with two end portions of the outer quartz glass tube 12. With a sealing substance, for example, solder frit, having been disposed on the end caps 16, 18, the assemblage of the outer quartz glass tube 12, the end caps 16, 18, and the inner quartz glass tube 14 is fired and sealed in an annealing oven.

The end caps 16, 18 would also have wiring voids 28 defined therewithin, in order to provide a pathway for the heater wiring 26, and a vacuum void 24 defined therewithin, in order to draw a vacuum within the space defined between the outer quartz glass tube 12 and the inner quartz glass tube 14. At least one vacuum grommet 22 would be used to seal and maintain the vacuum.

The composition of the heater wires 26, the outer quartz glass tube 12, inner quartz glass tube 14, the end

caps 16, 18, the connection means 32, the conductive coating 34, and the vacuum grommet 22 are chosen to increase the reliability of the vacuum insulated heater assembly 10. This is desirable since reliability diminishes as a result of the high heating conditions in and around the heater, which tends to accelerate chemical reactions among the materials that make up the vacuum insulated heater assembly 10. In addition, the vacuum is drawn within the space between the outer quartz glass tube 12 and the inner quartz glass tube 14 in order to minimize the ability for the aforementioned parts to chemically interact with the atmosphere that might exist within the vacuum insulated heater assembly 10.

Fig. 2 illustrates an end view of the vacuum insulated heater assembly 10 of Fig. 1, where the inner quartz glass tube 14 is concentric within the outer quartz glass tube 12. The end cap 18 mechanically attaches to and seals the inner quartz glass tube 14 within the outer quartz glass tube 12. The inner quartz glass tube void 38, vacuum void 24, and the wiring voids 28 are also shown in Fig. 2.

It should be appreciated that the present invention may be practiced where the outer quartz glass tube 12 has a cross-section other than tubular, the cross-section of the inner quartz glass tube 14 may not be tubular or circular, for example, a curved piece of glass or a cross sectional shape other than circular, the end caps 16, 18 are not disks or rings, the inner quartz glass tube 14 is not concentric

within the outer quartz glass tube 12, and/or an inert gas occupies the space between the inner member 14 and outer member 12.

Thus a preferred embodiment of the present invention provides the quartz glass heater 10 where the fluid to be heated is inside the tube 14 and the heat source 34 is outside of the tube 14, and the space between the two tubes 12 and 14 is evacuated. Due to the low emissivity of the coating 34, heat that is generated by electrical current being conducted through the coating 34 radiates into the inner member 14 but radiates very little heat directly from the coating 34 into the space adjacent to the coating 34 that is between the inner member 14, and the outer member 12. The coating 34 thus acts as a radiation barrier. In order to heat a fluid, the fluid flows through the inner member void 38 and heat radiates from the coating 34 toward the center of the inner member 14 thus heating the fluid flowing through the inner member void 38. In effect, the very efficient insulation provided by the space between the tubes 12 and 14 and the above stated properties of the low emissivity coating 34 is similar to a thermos bottle type of construction.

In order to heat objects, the shape of the inner member 14 need not be tubular and the electrically connected coating 34 may not be deposited on a large portion of the major surface 36, as would generally be the case in the above-mentioned fluid heater assembly 10. This would result

in the heat radiating through the inner member 14 and then away from the inner member 14 in those portions of the inner member 14 where there was no coating 34 on the major surface 36, into the space between the inner member 14 and the outer member 12, through the outer member 12, and on to the object to be heated.

In application, the heating of the vacuum insulated heater assembly 10 may be controlled by way of a conventional temperature sensor in the fluid stream, a temperature sensor attached to a wall of the outer quartz glass tube 12, a simple flow switch to energize the heater circuit when fluid is flowing, or other means conventional in the art.

In accordance with the provisions of the patent statutes, the principles and modes of operation of this invention have been described and illustrated in its preferred embodiments. However, it must be understood that the invention may be practiced otherwise than specifically explained and illustrated without departing from its spirit or scope.